IX.—*On some Points in the Morphology of the Rhabdophora, or true Graptolites**. By John Hopkinson, F.L.S., F.G.S.

Professor M'Coy, in his 'British Palæozoic Fossils,' published in 1854, in describing a graptolite from the Skiddaw Slates and other beds, to which he gave the name of *Graptolites latus*, speaks (p. 4) of "transverse diaphragms" being present near the base or proximal termination of the calycles (hydrothecæ), and shows the position of these diaphragms in a figure (pl. 1 B. fig. 7) which probably represents part of a branch of *Didymograptus patulus* or an allied species; but it is impossible to refer with certainty to any one species his aggregate *Graptolites latus*, now universally admitted to have been founded upon fragments of branching forms.

No further allusion appears to have been made to the presence of any diaphragms or septa until, in 1868, I stated (Journ. Quekett Microsc. Club, vol. i. p. 161) that I could find "no indication of a dividing septum" in graptolites "if we except a few forms in which there is an impressed line between the hydrothecæ and the periderm" (perisarc), which I then compared to that "at the base of the hydrothecæ in the Sertulariadæ." I accepted, however, the generally-received view that the graptolites agree with the Hydrozoa in their hydranths not having been cut off from the common cœnosarc by an actual entire or perforated septum, differing thus in their structure from the majority of the Polyzoa.

More recently Professor Allman, in his 'Monograph of the Calyptoblastic or Tubularian Hydroids' (Ray Society, 1872), not admitting the presence of any septum or constriction, has compared the calycles of the Rhabdophora to the fixed nematophores (sarcothecæ) of the Plumularidæ. He observes (p. 179) that "the denticles of the graptolite have their cavity uninterruptedly continuous with that of the main tube, there being no diaphragm or constriction of any kind at the point where the one passes into the other;" and, alluding to Prof. M'Coy's observations already mentioned, he says that he "speaks of a septum at the base of the denticles in certain graptolites, but subsequent observations have not tended to confirm this statement."

I have recently had the opportunity of examining an extensive collection of graptolites made by Mr. W. Kinsey Dover, F.G.S., from the Skiddaw Slates, mostly from Skid-

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daw and the adjacent hills, amongst which are a few specimens from Falcon Crag distinctly showing internal structure. The species of which the structure is most clearly defined are *Didymograptus extensus*, Hall, *D. patulus*, Hall, and *Tetragraptus serra*, Brong. (= *T. bryonoides*, Hall). In several specimens of these species the hydrothecæ are seen to be separated from the perisarc by a distinctly-marked septum; and the perisarc is, moreover, in specimens of all the three species, seen to be jointed, or crossed by transverse septa.

In a portion of a branch of *Tetragraptus serra* (fig. 1) this structure is particularly clearly seen. The specimen is preserved in section with its interior partly filled in with mineral matter differing altogether from the slaty matrix in which it is enclosed; and iron-pyrites has taken the place of its once chitinous external membrane.

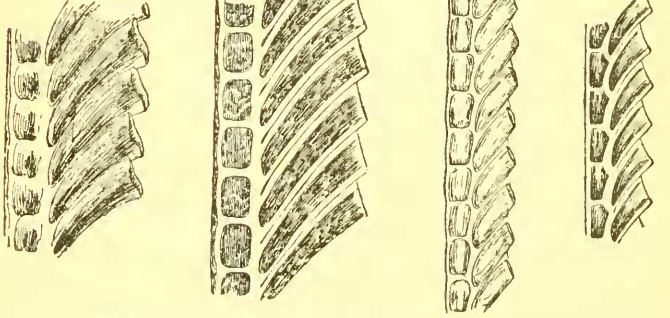
On the dorsal margin is the virgula with a wavy outline. Next to this is the perisarc or common canal which formed the channel of communication between the individual hydranths, looking where filled in like a jointed tube, and where the infiltrated mineral matter has been removed, or has never been deposited, appearing as a series of rectangular depressions divided from each other by transverse walls or, rather, distinct ridges; for they do not nearly fill up the space between the two sides of the perisarc. The hydrothecæ, where their interior is filled in with mineral matter, are each articulated with the corresponding rectangular cavity of the perisarc, a ridge or partial septum dividing them from it; and where their interior is not filled in they are divided from the perisarc and from each other by a perceptible ridge. They are curved, springing from the perisarc at an angle of from 30° to 40°, which gradually increases to 50°; and they are wider at their distal than at their proximal end, the margin of which is of a curved form, slightly flattened where in contact with the corresponding division of the perisarc. In one portion their external apertures are seen. Here and there the pyrites has filled up spaces which have probably been caused by the contraction of the infiltrated mineral matter, giving a few of the thecæ a jointed appearance; but this is evidently an accidental occurrence, and the *regular* jointing of

Fig. 1.—Part of a branch of *Tetragraptus serra*, natural size.

the sections of the perisarc and line of junction of the thecæ with it could not be thus explained.

In the other specimens examined very similar appearances are presented. In both *Didymograptus extensus* and *D. patulus* there is a jointed perisarc with thecæ distinctly separated from it. They appear, in fact, to have budded from it as the leaves of an exogenous tree bud from the stem or twig which supports them, and not to have been continuous with it as are the leaves of endogenous trees with their support. In this point it would seem that we have an analogy with the vegetable kingdom. It is well known that in some graptolites we frequently have the perisarc preserved without the calycles which should spring from it; and so may we have a tree without its leaves, though in both cases there has been organic connexion between the now disconnected members. In the graptolite, as in the tree, there is no actual septum; there is a ridge, a constriction, occasionally forming a very sharp line of demarcation, but in most cases scarcely, if at all, perceptible.

This "impressed line" I first noticed in 1868 in graptolites from the Lower Silurian rocks of the south of Scotland. In 1872 I found several specimens of the species *Monograptus bohemicus*, Barr., *M. Nilssoni*, Barr., and *M. leintwardinensis*,



Figs. 2, 2 *a*. Different portions of the branch of *Tetragraptus serra* represented in fig. 1, magn. 5 diameters.

Figs. 3, 3 *a*. Different portions of a branch of *Didymograptus extensus*, magn. 5 diameters.

Hopk., in the Ludlow rocks near Ludlow, more clearly indicating such a structure; but it is not until now that I have been able actually to see not only the external indication of a

dividing ridge, but the ridge itself, projecting into the internal cavity of the graptolite, and so clearly in some instances that when examined under the microscope its thickness can be measured and the extent of its projection estimated. The accompanying figures (figs. 2, 3) are reduced from drawings thus made with the microscope and camera lucida.

It would thus appear that in certain graptolites the calycles seem to be completely cut off from their supporting perisarc, this appearance being due to a constriction or the presence of a partially-dividing ridge, and also that in these same forms there are at least *constrictions* in the perisarc dividing it into sections, from each of which a calycle is produced. This is the structure which generally obtains in the recent Thecaphora; and I therefore think that it can now no longer be maintained that the calycles of the graptolite are not true hydrothecæ,—the conclusion arrived at from previous investigations into the morphology of the Rhabdophora, and especially of the reproductive organs of certain graptolites *, that they are the Palæozoic representatives of the recent Hydrophora, thus being confirmed by specimens from rocks which would naturally be supposed to be most unlikely to yield fossils showing minute internal structure.

That these appearances have not been more frequently seen is probably owing to the imperfect state of preservation in which the Rhabdophora usually occur, and the very rare occurrence of specimens in section with the interior removed.

Mr. Dover's collection of graptolites is probably the most complete which has hitherto been made from the Skiddaw Slates; and a careful examination of it might add considerably to the hitherto-known fauna of these beds. Some graptolites are shown by specimens in his possession to have attained a very large size, there being many single branches of *Didymograpti* and *Tetragrapti* about a foot in length, a few of which show no signs of termination at either end. Every division of the series has been diligently worked for fossils by him; but it is only from one bed, exposed at Falcon Crag, that specimens preserved in an uncompressed state and showing internal structure have been obtained.

* See Ann. & Mag. Nat. Hist. (ser. 4) vol. vii. p. 317.